

AMS 2010 (Atlanta,GA) Abstract
Surface/Atmosphere Interactions
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Title: Analysis of air-sea interactions in the NASA MERRA product

Abstract:

Interactions between the ocean and atmosphere influence the global energy and water balance through the exchange of heat, moisture and momentum. These interactions occur over a wide range of space and time scales and need to be properly represented in climate and reanalysis simulations. This study focuses on the representation of the turbulent latent and sensible heat fluxes in the newly developed NASA Modern Era Retrospective-Analysis for Research and Applications (MERRA). It is shown that MERRA achieves realistic estimates of the turbulent fluxes for many space and time scales although some deficiencies are noted. Comparisons are made at high resolution temporal scales with measurements from several research vessels while long term comparisons are made with moored buoys. These results are contrasted with those from several other currently available reanalysis and satellite based products. The representation of feedbacks between the atmosphere and ocean are also examined through the use of simultaneous and lagged correlation analyses with particular focus on precipitation and sea surface temperature relationships. Together, these results demonstrate the consistency of the NASA MERRA product and its applicability for process studies across wide ranging scales of variability.

Analysis of air-sea interactions in the NASA MERRA product

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Background

Interactions between the oceans and atmosphere influence the global energy and water balance through the exchange of heat, moisture, and momentum. It is important that any numerical model properly represent these key processes, in particular the turbulent heat fluxes. The NASA Modern Era Retrospective-Analysis for Research and Applications (MERRA; Bosilovich et al. 2008, *J. App. Met.*) is a newly developed reanalysis product with specific aim at improving the representation of important hydrological processes. This study looks to provide a quantitative understanding of how faithful MERRA is with respect to surface layer exchanges over the ocean and their relationship to other hydrological cycle features.

Objectives:

- Validate MERRA on different time and space scales using direct near-surface observations.
- Examine known feedback mechanisms between the ocean and atmosphere in MERRA and observations.
- Examine fidelity of large-scale relationships between sea surface temperature (SST) and precipitation.

Observational Database

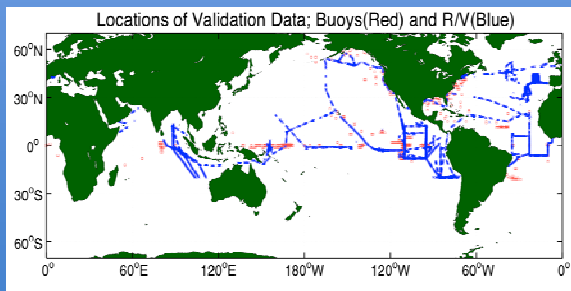


Figure 1. This figure depicts the locations of the primary in-situ observations used for validation purposes in this study. These observations have been quality controlled and combined for use in the SeaFlux (Clayson 2010, *in prep.*) intercomparison product.

High Resolution Observational Comparison

MERRA is a unique reanalysis in that hourly output is available for use in research studies. The following is an example of how sub-

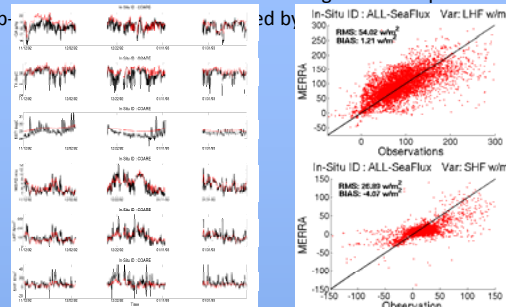


Figure 2. Direct matches have been made at hourly resolution to observations from the Coupled Ocean Atmosphere Response Experiment (COARE). It can be seen that MERRA is able to reproduce much of the sub-daily variability although it appears the amplitude of is slightly underestimated. A notable exception is that of SST as MERRA is forced using a weekly SST estimate. Areas in which diurnally-varying SSTs are important may lack an important component of high frequency surface forcing. Also shown are overall statistics for the high-resolution turbulent flux comparisons.

Long-Term Observational Comparison

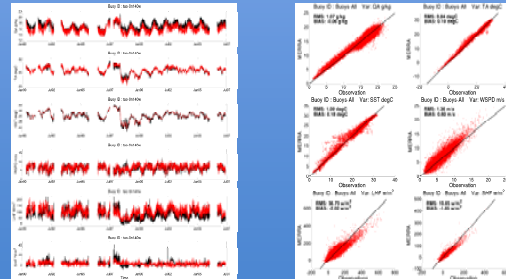


Figure 3. This figure depicts long-term daily resolution comparison between MERRA and moored buoy observations. The left panel depicts an example time series for a TAO buoy located at 0n, 140w. An apparent bias is seen in the near surface humidity field. The right panel show statistics covering all buoy locations. It is found in this study MERRA underestimates near-surface humidity for a majority of the TAO buoys. The source of this bias may lie in the convective and/or turbulent physics parameterization.

Ocean-Atmosphere Feedbacks

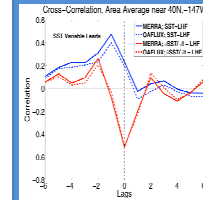


Figure 4. This figure depicts point cross-correlations between the latent heat flux (LHF), SST, and SST tendency. Correlations are computed between monthly anomalies w.r.t the seasonal mean. Also shown are results using the observation-reanalysis blended flux product OAFux (Yu and Weller 2007, *BAMS*). This cross-correlation structure is indicative of a negative feedback mechanism.

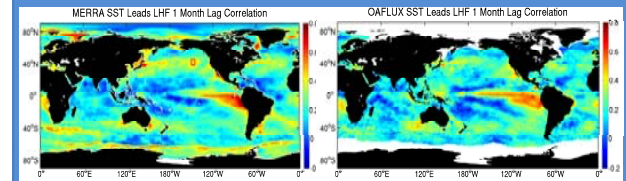


Figure 5. (-)1 month lag correlations are shown between LHF and SST for MERRA and OAFux. These products show many common features but it appears that MERRA typically overestimates the strength of coupling, particularly in the North Pacific. The red square outlines the area used for the point correlation in Figure 4.

Large scale SST-Precipitation Relationship

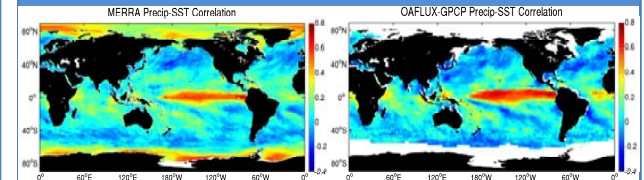


Figure 6. Large scale simultaneous correlations are shown for MERRA and between OAFux SST and GPCP v2.1. While overall agreement is seen, there are some issues particularly over the western Pacific warm pool region where observations show negative correlations and MERRA shows near-zero to slightly positive correlations. This is also a region of slight disagreement between feedbacks shown in Figure 5.

Conclusions

- MERRA is able to capture sub-daily variability in a realistic fashion, albeit with reduced amplitude. Diurnal SST variability is absent.
- Long-term comparisons reveal a possible near-surface dry bias over the tropical Pacific region. This bias may vary in time.
- The strength and direction of ocean-atmosphere coupling, in the form of LHF-SST feedbacks and SST-Precipitation, is generally well captured. Some discrepancies exist, particularly in the western Pacific.